Laser Gas Cell Devolopments at LISOL

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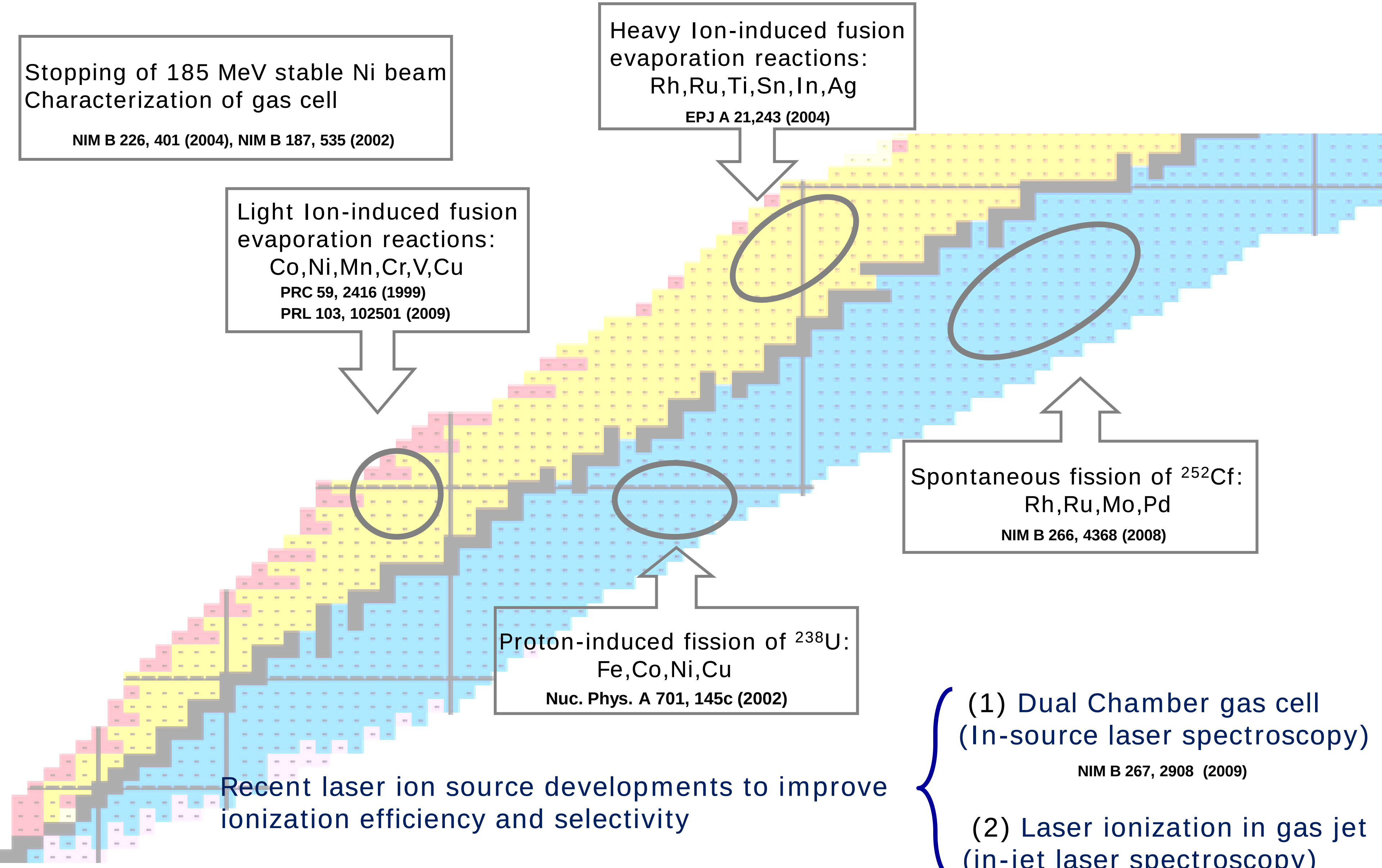
BriX

KATHOLIEKE UNIVERSITEIT LEUVEN

LISOL Beams since 1994

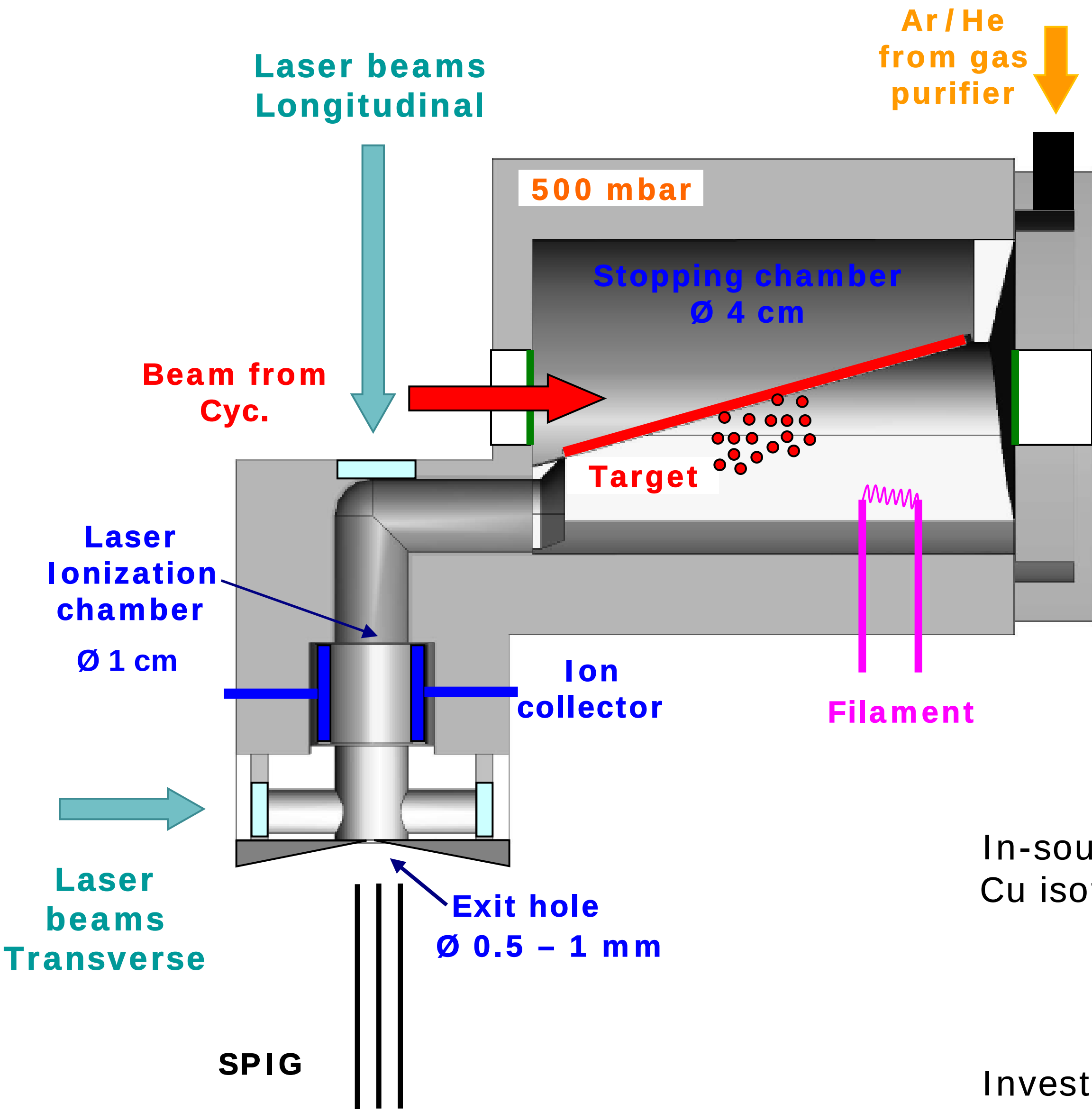


Recent laser ion source developments to improve ionization efficiency and selectivity

(1) Dual Chamber gas cell
(In-source laser spectroscopy)
NIM B 267, 2908 (2009)

(2) Laser ionization in gas jet
(in-jet laser spectroscopy)
NIM B 267, 2918 (2009)

Dual Chamber Gas Cell



By separating stopping and laser ionization volumes

- Increased laser ionization efficiency at high cyclotron beam current
- Increased selectivity (collection of survival ions)

Fusion evaporation reaction of ^{94}Rh

Selectivity:

Laser(ON)/Laser(OFF)

Ion Collector OFF = 450

(200 for 1st generation GC)

Ion Collector ON = 2200

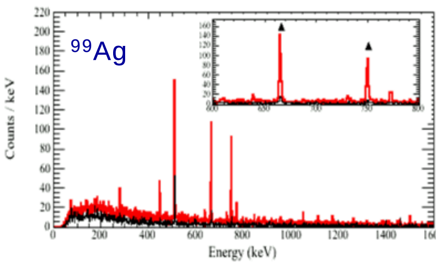
In-source spectroscopy of neutron deficient Cu isotopes using the dual chamber gas cell

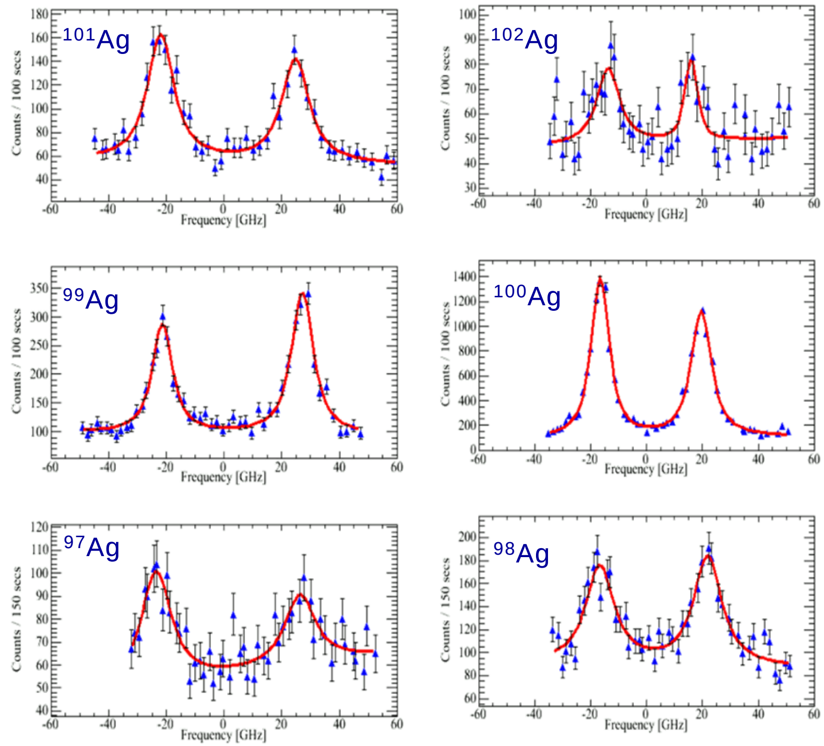
PRL 103, 102501 (2009)

Investigate possibility of performing similar measurements near N=Z line around A=100

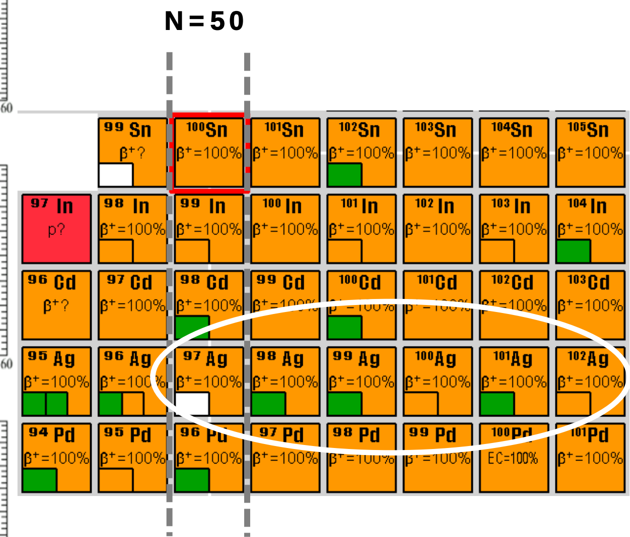
In-Cell Laser Spectroscopy of Ag

γ-singles



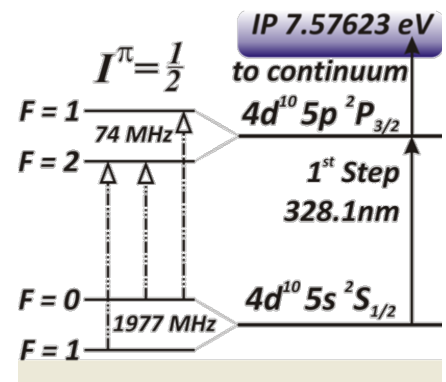


^{14}N @150 MeV on ^{92}Mo



Voigt fit:

- Gaussian fixed to 1.4 σ (3.3 MHz) based on signal from RC
- Lorentzian free



	Splitting (GHz)	I^π	μ_{exp}(tot.) (nm)	μ_{exp}^{lit} (nm)
102	29.7(1.6)	5^+	3.57(19)	4.6(7)
100	36.2(3)	5^+	4.35(3)	--
98	38.1(8)	5^+	4.58(10)	--
	38.1(8)	6^+	4.651(10)	--
101	46.8(3)	$9/2^+$	5.57(3)	5.7(4)
99	48.7(3)	$9/2^+$	5.80(4)	--
97	50.6(1.0)	$9/2^+$	6.02(13)	--

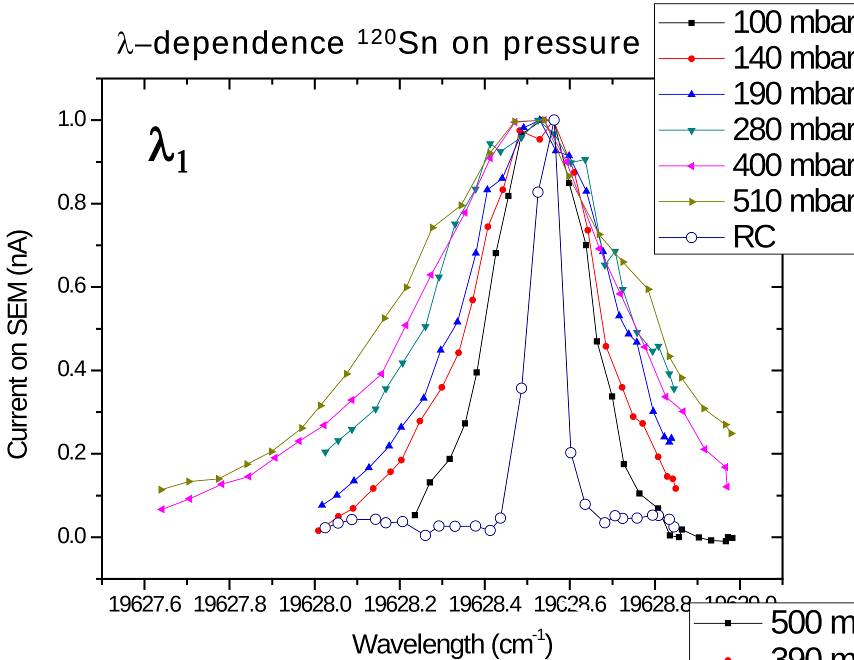
$^{97\text{-}100}$Ag experimentally determined for the first time

PLB Iain Darby (in preparation)

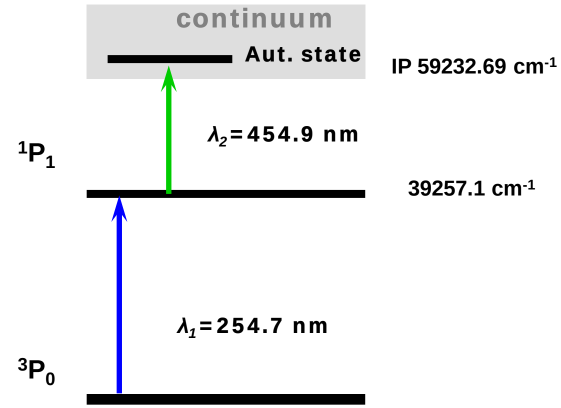
Only preliminary – comparison with shell model calculations still to be done -

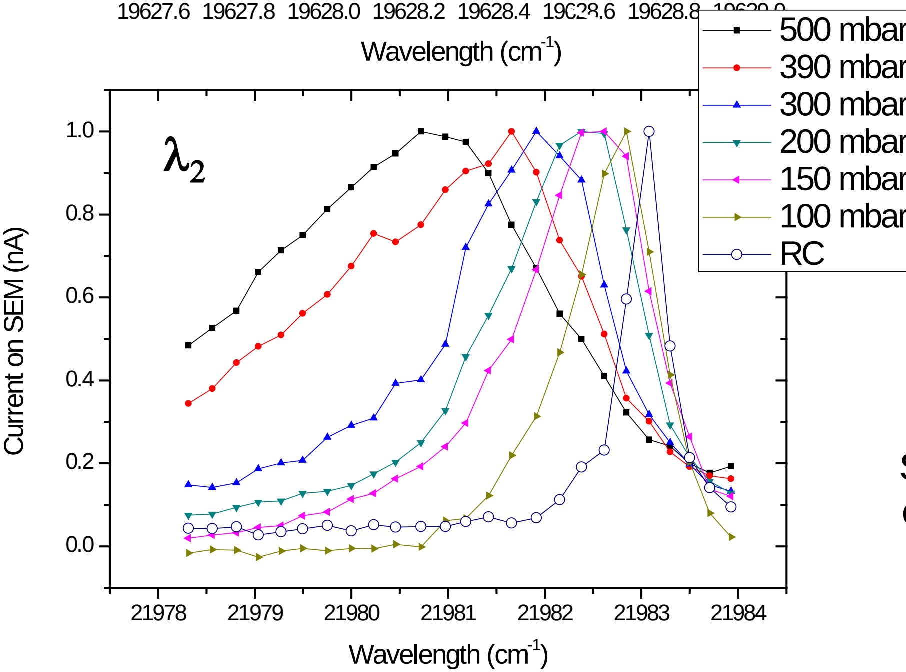
An Attempt at Sn

	^{57}Cu	^{58}Ni
Broad.(MHz/mbar)	5.4	11.3
Shift .(MHz/mbar)	1.9	5.5



Shift = 4.0(0.3) MHz/mbar
Broadening=32(4) MHz/mbar



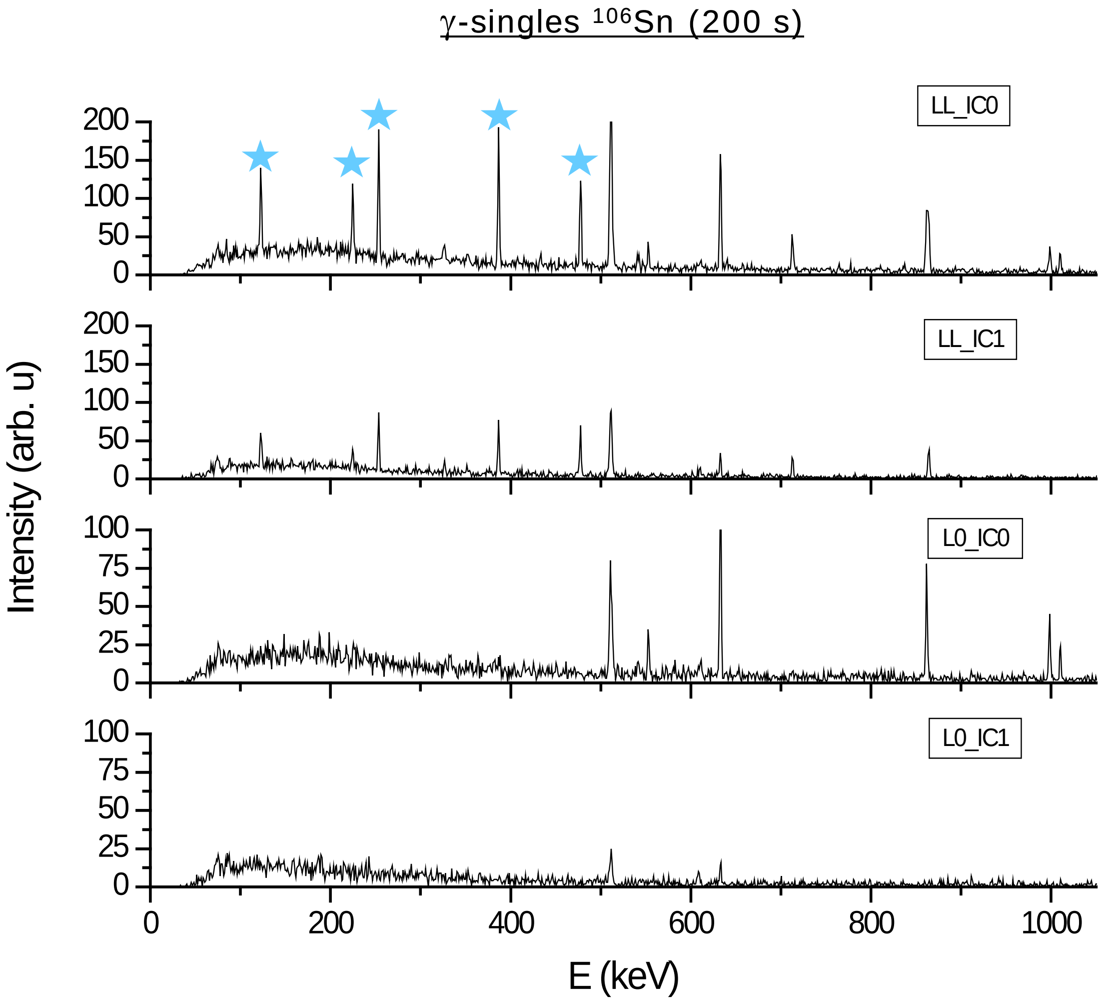


Shift = 150(10) MHz/mbar
Broadening=210(25) MHz/mbar

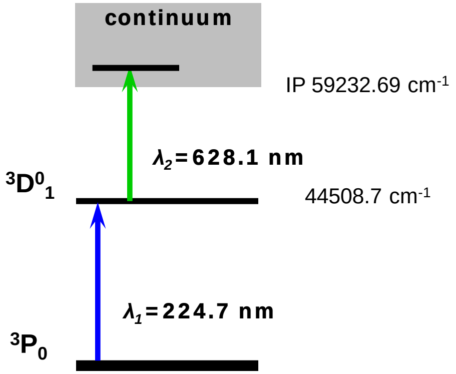
Strong dependence of λ_2 with pressure → Autoaionizing state with Rydberg nature !?

Ryberg states are very sensitive to external influences such as collisions

An Attempt at ^{106}Sn



- Change to ionization scheme with lower n
- Pressure shift consistent with stable isotopes



^{106}Sn

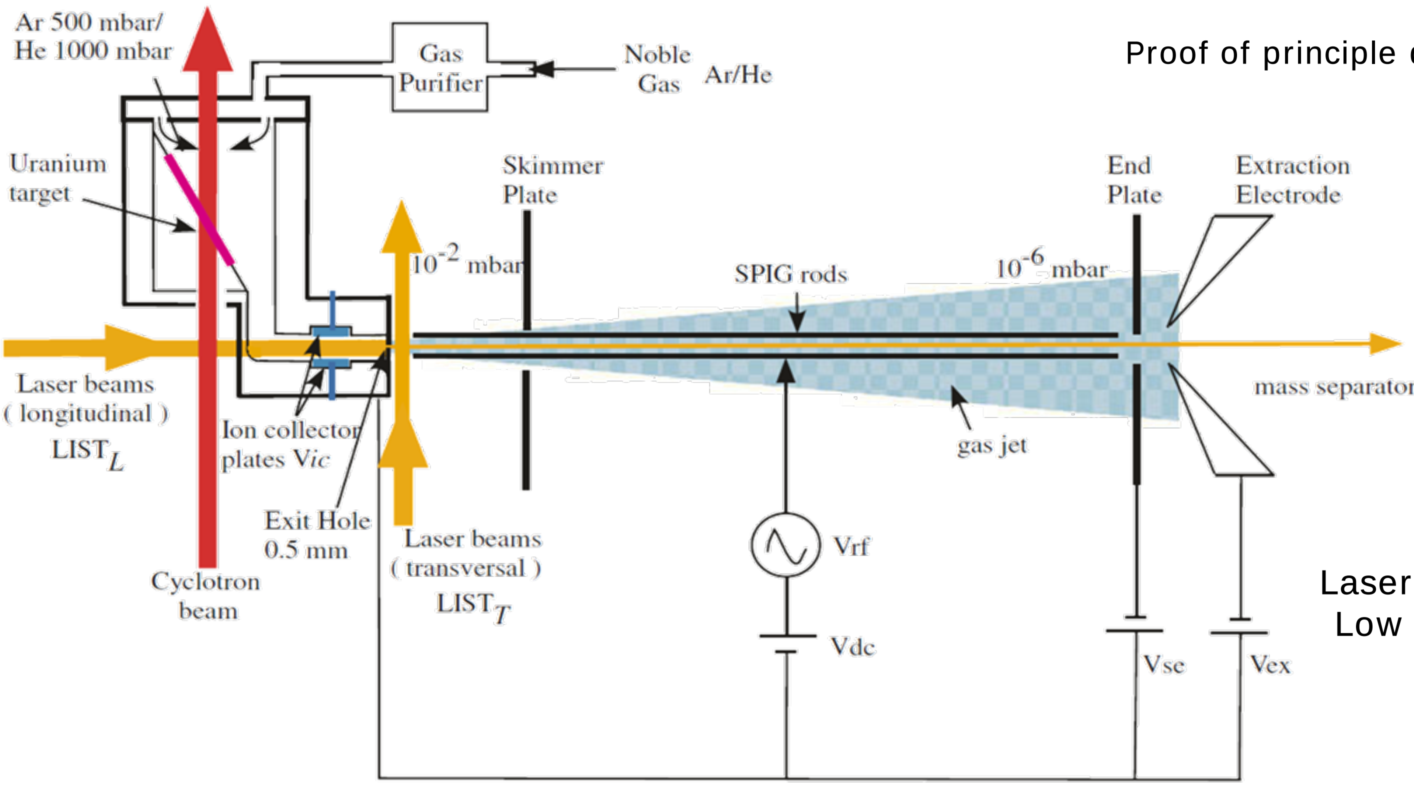
$\varepsilon_{prod.}$ = 0.40(2)%

Selectivity
52(15) IC on
40(11) IC off

In-jet Laser ionization / spectroscopy- LIST

❑ Low density and low temperature inside the jet makes velocity distribution nearly uniform
❑ Small pressure and Doppler broadenings

Proof of principle demostrated at LISOL



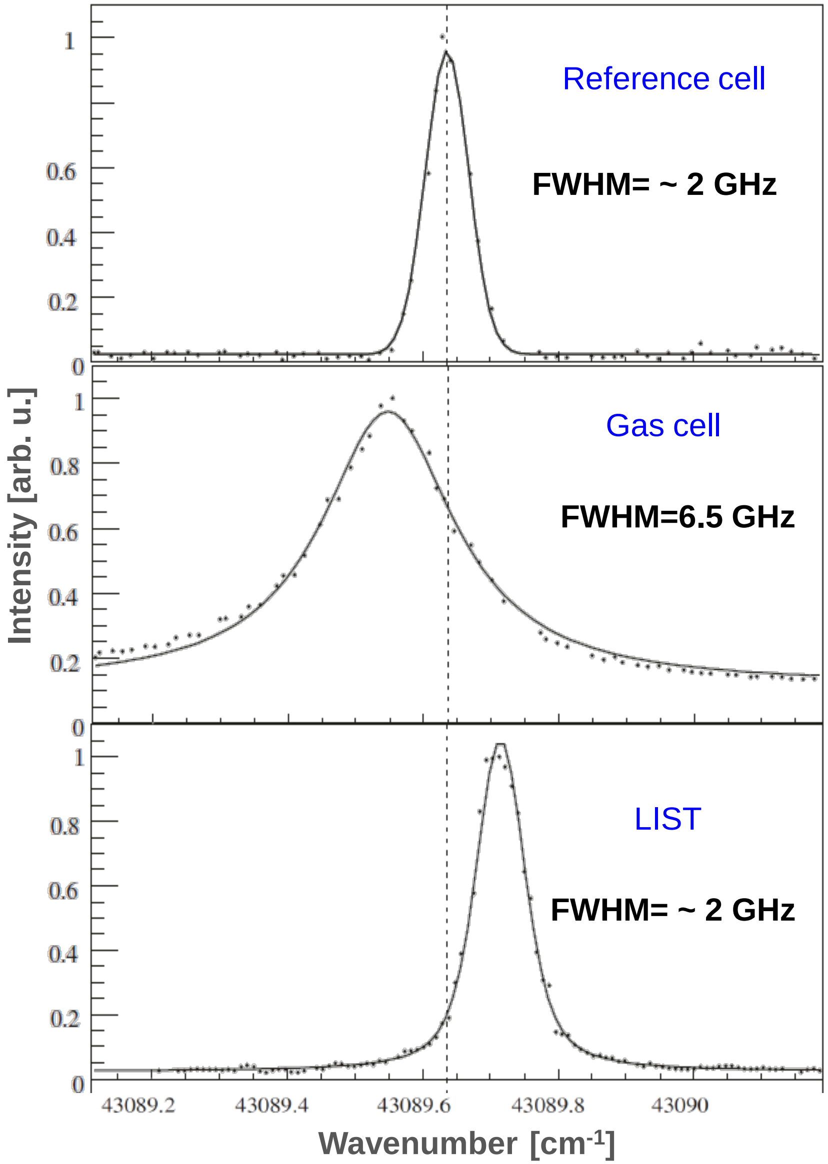
Main limitations:
Laser beams through exit hole
Low repetition rate of lasers

- Gas jet as an environment for laser spectroscopy is much more comparable to that of vacuum conditions

- In the gas cell pressure is a crucial parameter to determine the resonance width

Laser spectroscopy: Gas cell vs. LIST

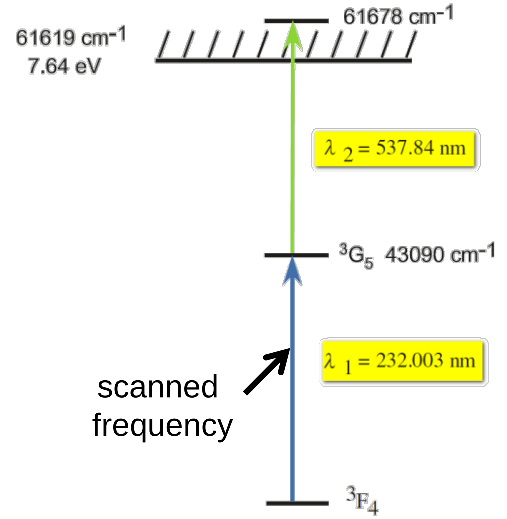
Resonant linewidths of the first step transition of Ni



Laser band width ~1.6 GHz, (excimer-pumped dye lasers, second harmonic)

Red shift of 2.5 GHz: pressure dependence

Doppler shift due to jet velocity: ~560 m/s

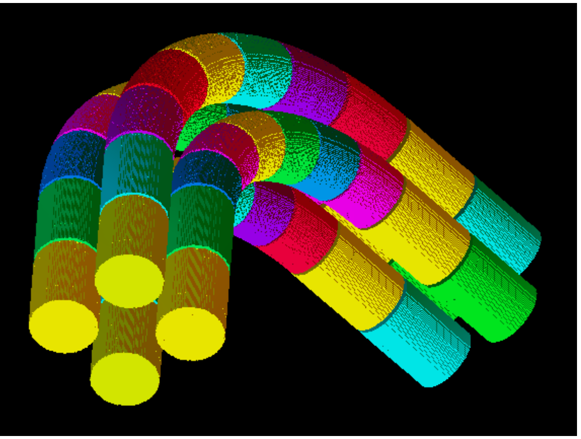


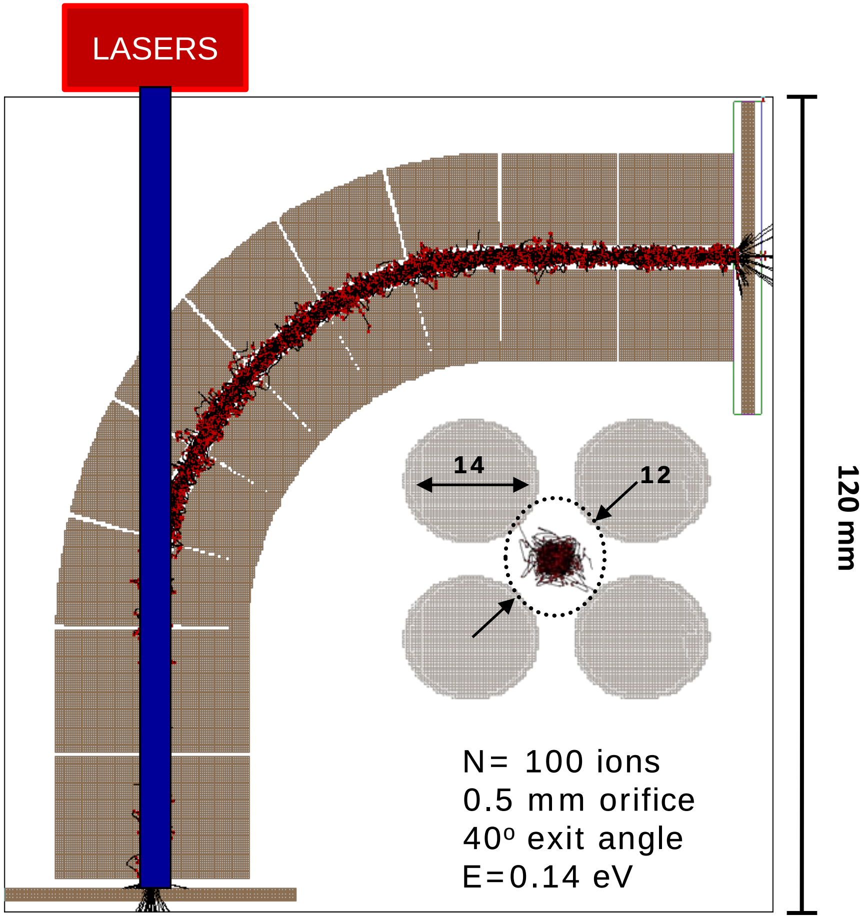
List mode:
higher resolution
&
better selectivity

Requirements prior to implementation:
Improve overlap of laser light with atoms

- time overlap: High repetition laser system
- geometrical overlap: special nozzel + CRFQ

Curved RFQ for LIST Laser Spectroscopy





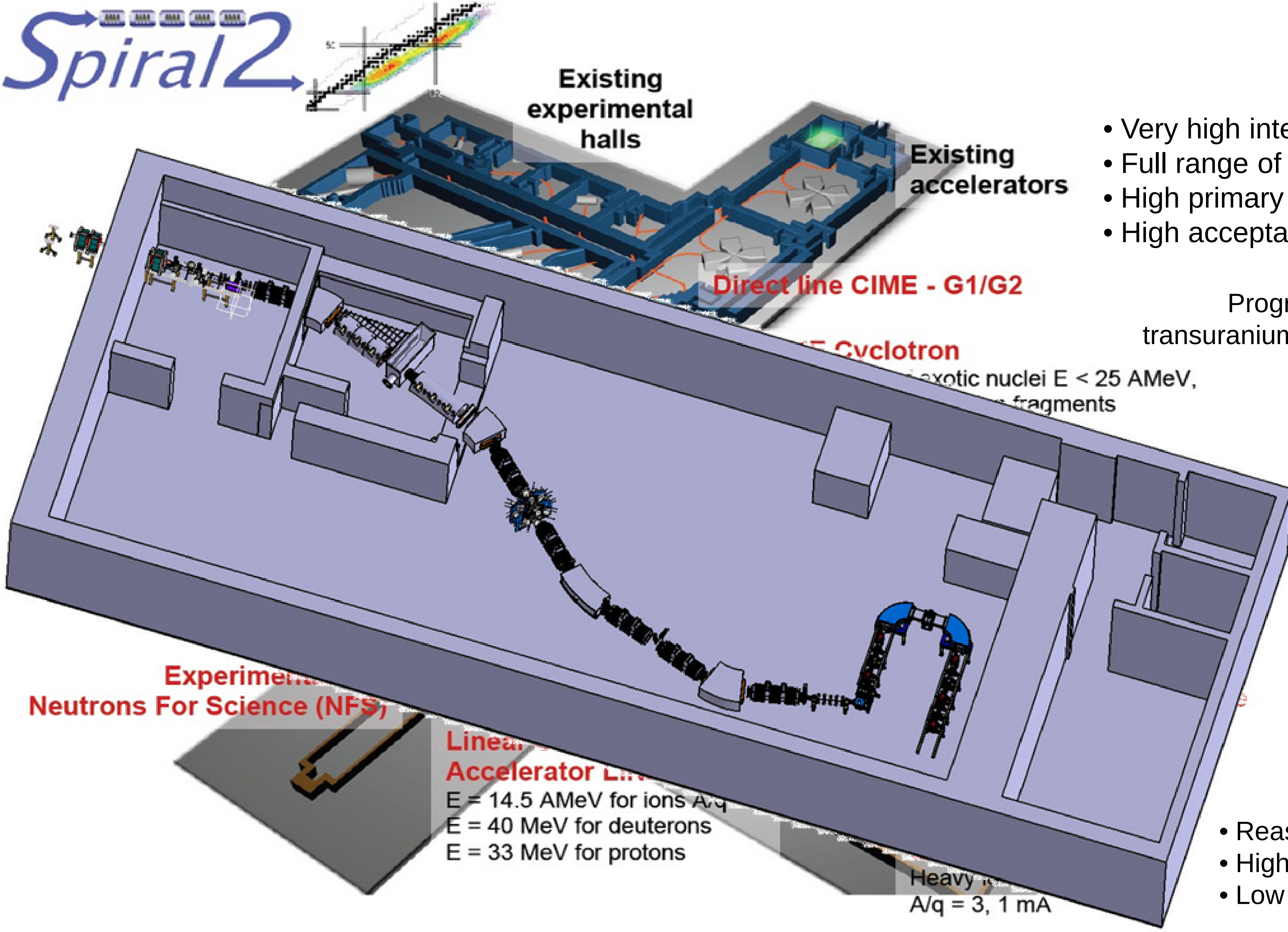
SimIon simulation

M= 58 u
M_{buffer}= 40 u
Vrf=200 Vpp
Ω = 1MHz
Vdc= 3 V between segments
HS ion-neutral collision model
p=0.1 mbar
T=300 K
e(Trans)~ 60%

Still to be implemented:
- Pressure gradient
- Shorter segments

CRFQ with segmented electrodes:
-Test LIST with full geometrical overlap @ LLN (Laval nozzle)
-Better pressure conditions (beam line out of the jet's path)
- Bigger diameter gas cell exit hole...

S³ – low energy branch @ SPIRAL2



- Very high intensity primary beams
- Full range of primary beams (H to U)
- High primary beam rejection
- High acceptance spectrometer

Programme to study transuranium elements at SPIRAL2

<u>Benefits:</u>

- Reasonable prod. yields
- Higher Z → higher hfs
- Low Doppler and p broadening

Research and development phase at CRC-LLN:

- Laser ionization schemes (Ac, At,….)
- Laser band width, power, and repetition rate (Test of high repetition rate lasers (10kHz) at LISOL) → **LIST mode**